Evaporative Fraction

\[ \text{Evaporative Fraction} = \frac{\text{Latent Heat Flux}}{\text{Total Available Energy}} \]

Figure 1

While hydroclimatic trends are often defined through temperature and precipitation observations, trends in surface energy fluxes are seldom reported due to sparse data. The National Climate Assessment Land Data Assimilation System (NCA-LDAS) was recently used to quantify trends in U.S. energy fluxes for 1979-2015. The trend in mean summer Evaporative Fraction reveals a significant East-West gradient, with important implications ranging from science to decision support.
Technical Description of Figures:

Figure 1. Evaporative Fraction (EF) is the ratio of the land surface latent heat flux expressed in Watts/m² to the total available energy. It is formulated from the land surface energy balance equation where the total available energy is computed as net radiation minus ground heat flux or the sum of latent and sensible heat fluxes. Advected energy is assumed negligible.

Figure 2. The summer EF trend is computed from 36 years (1979-2015) of June/July/August daily output from the NCA-LDAS land reanalysis. Trends are computed for each model grid box using the Mann-Kendall Test. Only statistically significant trends passing p<0.1 are reported with non-significant trends white. EF trends reveal an East-West gradient, with positive trends in the East changing to negative trends in the West. These trends are primarily a manifestation of i) an overall increasing trend in temperature throughout the US during 1979 to 2015, and ii) the precipitation trend gradient, with precipitation increasing in the East and decreasing in the West.

Scientific significance, societal relevance, and relationships to future missions

The scientific significance of the EF trend is that it reveals that the overall increase in available energy due to global warming is disproportionately consumed by latent heat relative to sensible heat. The EF trends therefore have important implications for understanding climate change and for decision support, especially for water resources, agriculture, and ecology. For instance, decreasing EF trends may represent soil drying and drought. Increasing EF may represent increasing productivity or growing season. Change in EF may ultimately be reflected in changes in natural habitat and species migration. Future decision support tools may need to factor in these trends.

The above result is one of NASA’s contributions to the United States Global Change Research Program’s National Climate Assessment. NCA-LDAS represents NASA’s first multivariate satellite data assimilation model, that employs the Noah Version 3.3 land surface model forced with NLDAS-2 meteorology, Climate Prediction Center precipitation, and assimilated satellite soil moisture, snow depth and irrigation intensity products. NCA-LDAS satellite data assimilation has shown to improve trend detection compared to the non-data assimilation version. Both daily and trend NCA-LDAS data products are publicly available, allowing science and applications communities to formulate other hydroclimatic indicators for scientific understanding and decision support.
Daily large-scale terrestrial water storage variations recovered by GRACE

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Daily changes in terrestrial water storage are observed by GRACE and GRACE-Follow On and can be recovered over large spatial scales. This recovery is limited by GRACE’s daily orbit tracks, but areas such as the Arkansas-White-Red basin or the Missouri basin are large enough to be meaningfully recovered. All but the driest locations contain large enough signals to be recovered.
References:

Data Sources: NLDM hourly gridded products used in this study were acquired as part of the mission of NASA’s Earth Science Division and archived and distributed by the Goddard Earth Sciences (GES) Data and Information Services Center at https://disc.gsfc.nasa.gov/. The GSFC monthly mascon product is available through the Geodesy and Geophysics Science Research Portal at GSFC, https://earth.gsfc.nasa.gov/geo/data/grace-mascons/. GRACE Level-1B data are available through PO.DAAC, https://podaac.jpl.nasa.gov/. USGS HUC 2 basin definitions are available online, https://water.usgs.gov/GIS/huc.html.

Technical Description of Figures:
**Figure 1:** The daily orbital coverage of the GRACE and GRACE-FO missions creates the largest limitations on our ability to recover daily signals. We use information from our estimation system to develop a metric that describes the spatial resolution of the solution at any location. A resolution of 400 km means that the recovered signal at that location represents signal from within a disc with approximately 400 km radius. Areas nearest GRACE tracks show the best (smallest) resolution, and areas near multiple tracks show further improvements.

**Figure 2:** Recovered daily variability in terrestrial water storage is shown for the Arkansas-White-Red basin (in red). These variations are relative to the monthly estimates already captured in the GSFC monthly mascon product (and other GRACE monthly solutions). We compare these recovered variations to two model outputs (VIC, in black, and Noah, in blue) from the North American Land Data Assimilation System (NLDAS). In the paper, we make these comparisons for 15 basins of varying sizes in North America and determine the minimum basin size that can be observed daily.

**Figure 3:** A map of Signal-to-Noise is shown relating signal in our new daily solution to estimates of noise and bias errors in the solution. We show that all but the driest land locations can be observed globally, and areas with large signals such as wet river basins have significant signal recovery. We are therefore recovering meaningful daily signals that are averaged out of monthly GRACE solutions.

Scientific significance, societal relevance, and relationships to future missions: Most GRACE and GRACE-FO data products have focused on capturing monthly variability in Earth’s gravity field, typically driven by changes in the total amount of water stored on Earth’s land surfaces as either groundwater, surface water, snow, or ice. By capturing daily variations, this work extends the applications of GRACE and GRACE-FO to cases requiring sub-monthly information, trading spatial resolution for temporal resolution. We extend the analysis in Figure 3 to establish expectations of signal recoverability at high-, mid-, and low-latitude locations for sub-monthly solutions with time scales ranging from 1- to 14-day solutions. The 2017 Decadal Survey identified high-level questions pertaining to global hydrological cycles and water resources which require timely quantification of surface mass change due to changes in TWS, including a need to monitor and understand the coupled processes that change water quality, fluxes, and storages and a need to improve drought monitoring to forecast short-term impacts more accurately and to assess potential mitigations. The results of this study establish methods and metrics for applying GRACE and GRACE-FO’s unique global view of changes in the total water column to these problems on sub-monthly timescales.
RadCalNet data were recently used to provide an SI-traceable, absolute radiometric calibration of the eMAS (Enhanced MODIS (Moderate Resolution Imaging Spectroradiometer) Airborne Simulator) sensor as part of an overflight of opportunity of the Railroad Valley RadCalNet (Radiometric Calibration Network) site during the FIREX-AQ (Fire Influence on Regional to Global Environments and Air Quality) campaign. The results show the utility of how RadCalNet data can be processed for airborne imagers and the flexibility of automated ground measurements allowing for such calibrations of opportunity.
References:


Data Sources: Data sources in this work include: eMAS, FIREX-AQ, RadCalNet

Technical Description of Figures:
Figure 1: eMAS browse imagery of the Railroad Valley Playa, Nevada test site and GSFC RadCalNet member cross-calibrating a field transfer radiometer and one of the RadCalNet radiometers at Railroad Valley.
Figure 2: Comparison of RadCalNet-based predictions of at-aircraft spectral radiance and eMAS measurements for the Railroad Valley overflight.

Scientific significance, societal relevance, and relationships to future missions: A key element to Decadal Survey Programs of Record are data quality and consistency. Radiometric Calibration Network (RadCalNet) data provide a data set comparable to known standards and suitable for calibration of imagers in the solar reflective based on automated ground measurements. The data shown here provide an example of how RadCalNet data can be expanded for the absolute radiometric calibration of airborne imagers making flights of opportunity without the need to coordinate with a field validation team.
Here we present new estimates of sea ice thickness derived from ICESat-2 freeboards – satellite measurements of sea ice height above sea level - for the first Arctic winter season (October 2018 to April 2019) of data collection.

We utilize snow loading estimates from the NASA Eulerian Snow on Sea Ice Model (NESOSIM) to convert freeboard to thickness.

Our February/March 2019 thickness estimates are ~20% thinner than our February/March 2008 thickness estimates from the original ICESat mission.
References:

Code Source: Our sea ice thickness processing code is on GitHub: https://github.com/akpetty/ICESat-2-sea-ice-thickness

Data Sources:
Along-track (doi: 10.5067/JTI5YG3S6VAJ) and gridded (doi:10.5067/CV6JEXEE31HF) ICESat-2 sea ice thickness estimates presented in this study are available through the National Snow and Ice Data Center (NSIDC). The data include the key input data and uncertainties as explained in more detail in the data portals. The gridded thickness data repository also includes the gridded spring ICESat thickness data presented in this study. The ICESat-2 ATL10 sea ice freeboard data (designated Release 002 used in this study) can be obtained from the NSIDC (https://nsidc.org/data/atl10).

Technical Description of Figures:
Figure 1: Monthly ATL10 ICESat-2 freeboards, coincident (redistributed) snow depths from the NASA Eulerian Snow on Sea Ice Model (NESOSIM) and estimated sea ice thickness for November (top) and December (bottom). The magenta line shows the 50% ice concentration contour taken from the NSIDC Climate Data Record (CDR) passive microwave dataset and the black line shows the first-year ice/multi-year ice boundary from the Ocean and Sea Ice Satellite Application Facility (OSI SAF) ice type product.

Scientific significance, societal relevance, and relationships to future missions:
NASA's ICESat-2 mission was launched in September 2018 with the primary goal of monitoring our rapidly changing polar regions. The sole instrument onboard is a highly precise laser which is now providing routine, very high-resolution, surface height measurements across the globe, including over the Arctic and Southern Oceans. In this study we show new estimates of Arctic sea ice thickness from the first winter-season of data collected by ICESat-2. Sea ice thickness is calculated by combining the measured ICESat-2 freeboards - the extension of sea ice above sea level - with a new snow on sea ice model. Our derived thicknesses are consistently lower than the thicknesses calculated from ESA's CryoSat-2 data and the original ICESat mission, which ended in 2008. Work is on-going to validate these new thickness estimates and deliver an automated sea ice thickness dataset.